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DATATRAN: DATUM TRANSFORMATION SOFTWARE Anthony R. Niles Mechanical Engineer U.S. Army Engineer Topographic Laboratories Ft. Belvoir, VA 22060-5546

BIOGRAPHICAL SKETCH

Anthony R. Niles is a Mechanical Engineer graduate of Old Dominion University. His initial projects at the U.S. Army Engineer Topographic Laboratories (USAETL) were with survey and navigation systems for the military. He currently works with the Surveying and Mapping Program for the Topographic Developments Laboratory.

ABSTRACT

This report will present software developed at USAETL and the National Geodetic Survey (NGS) to convert between the North American Datum of 1927 and the North American Datum of 1983. This program was developed in response to a need by the Corps of Engineers' Districts for accurate and easy-to-use software. report will concentrate on the program capabilities and procedures for use with only brief and general mention of conversion technique.

INTRODUCTION

The North American Datum of 1927 (NAD27) has become unsuitable for present-day surveys. Satellite surveys and accuracy requirements of conventional surveys have dictated the need for a more accurate earth-centered datum. American Datum of 1983 (NAD83) is replacing the NAD27.

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In anticipation of this transition, The National Geodetic Survey developed a computer program to convert survey data from NAD27 to NAD83, or vice-versa. This program, called LEFTI, converts geodetic positions (latitude/longitude) using a least squares adjustment. Since Corps of Engineers' Districts often use state plane coordinates, two other programs were developed to convert between geodetic positions and state plane coordinates on Thus, if a user desired to convert between NAD27 either datum. and NAD83 using state plane coordinates, two or more program runs The output from one program was used as the input were required. to the next program. In order to simplify this process, USAETL combined all three programs into one software package, called It also be the comment open inter DATATRAN. Private A 1825 The second of the second Transformation Technique

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As with the program LEFTI, DATATRAN uses a least squares routine to convert between NAD27 and NAD83. At least three reference stations with coordinates in both the old and new

datums are needed. The shifts in these reference stations are applied to the new stations to obtain coordinates in the new datum. Therefore, the accuracy of the transformation is dependent on the accuracy of the reference stations. If first-order reference stations are used, then first-order accuracy is obtained in the transformation.

State Plane or Geodetic Capability

With the integration of the state plane-geodetic conversion programs, DATATRAN offers the flexibility, in some cases, of having inputs/outputs in state plane or geodetic values. If inputs are in state plane coordinates, then the positions are converted to geodetic values for use in the NAD27-NAD83 conversion. If state plane outputs are desired, then the geodetic values output by the NAD27-NAD83 conversion are transformed to state plane values. The current software version does not have the capability of converting NAD83 state plane positions to geodetic values. Therefore, state plane inputs are not available for NAD83 to NAD27 conversions. The following conversions are available with DATATRAN:

- 1) NAD27 State Plane to NAD27 Geodetic
- 2) NAD27 Geodetic to NAD27 State Plane
- 3) NAD27 Geodetic to NAD83 Geodetic
- 4) NAD83 Geodetic to NAD27 Geodetic
- 5) NAD83 Geodetic to NAD83 State Plane
- 6) NAD27 Geodetic to NAD83 State Plane
- 7) NAD27 State Plane to NAD83 Geodetic
- 8) NAD83 Geodetic to NAD27 State Plane
- 9) NAD27 State Plane to NAD83 State Plane

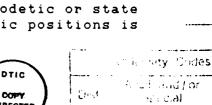
<u>Data Input</u>

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Data are entered into DATATRAN for NAD27-NAD83 conversions through two data files. These files follow formats specified in the Federal Geodetic Control Committee publication, 'Input Formats and Specifications of the National Geodetic Survey Data Base.'

The common point file contains the coordinates on the new datum of the reference, or common, stations. Thus, if NAD83 coordinates are being transformed to NAD27 positions, then this file would contain the NAD27 values for the common stations. Each line in the data file contains the station name, latitude, longitude, and other pertinent information for one station. The format for each station is given in Format A in the Appendix.

The control point file contains the coordinates on the old datum of the stations to be transformed. This file also contains the coordinates on the old datum of the common stations. As with the common point file, each line contains information for one station. The station coordinates can be in geodetic or state plane values. The format for a file of geodetic positions is



DTIC COPY INSPECTED given in Format B in the Appendix. Format C gives the structure for state plane coordinates.

Data Output

The output file for geodetic positions follows the same format as the control point file (Appendix, Format B). State plane outputs are listed with the geodetic values in an easy-to-read format. A file of conversion statistics for NAD27-NAD83 conversions is also produced. This file presents the shifts at each station, rotation, residuals, and other information concerning the datum shift.

As mentioned previously, DATATRAN presents the flexiblity of having some inputs/outputs in state plane or geodetic coordinates. The user may perform simple state plane-geodetic conversions on either datum. Inputs for these conversions can be entered interactively or through a data file (batch input).

Sample Program Run

The following presents a sample program run converting NAD27 geodetic coordinates to NAD83 geodetic coordinates. Five common stations and one control station are used. The common file and control file are created prior to the program run using the computer system editor. The common file, following Format A in the Appendix, is as follows:

DUP 1924 - SAMPLE FILE HURST 1905 - SAMPLE FILE TACOMA 1905 - SAMPLE FILE SAMPLEV459 - 1986 - FILE RAIN 1905 - SAMPLE FILE 47070784536N122395238255W 47050081643N122304811749W 47043710622N122260856576W 47100935002N122364326962W 46500533690N122411257305W

Examining the first record, there is a station named DUP 1924 - SAMPLE FILE with a latitude of 47 degrees, 7 minutes, and 7.84536 seconds north; and a longitude of 122 degrees, 39 minutes, and 52.38255 seconds west. The other four stations follow similar formats. Note the alignment of the data in each record into specific columns according to the format specification. Any deviation from this alignment will cause a program error or a misread of the data. Since this program run is converting from NAD27 to NAD83, the coordinates are the NAD83 positions of the common stations.

The control file, following Format B in the Appendix, is as follows:

*80 *	DUP 1924-SAMPLE FILE	47070848400N122394793300W
*80 *	TATSOLO 1935-SAMPLE FILE	47072948600N122392914900W
80	HURST 1905-SAMPLE FILE	47050145800N122304367300W
80	TACOMA 1905-SAMPLE FILE	47043774600N122260413000W
*80 *	SAMPLEV459-1986-FILE	47100935002N122364326962W
80	RAIN 1905-SAMPLE FILE	46500597300N122410813200W

This file contains the NAD27 geodetic positions for the common stations and the control station. Examining the first record, there is a station named DUP 1924 - SAMPLE FILE with a latitude of 47 degrees, 7 minutes, and 8.48400 seconds north; and a longitude of 122 degrees, 39 minutes, and 47.93300 seconds west. The other five stations follow similar formats.

Having created the common and control files, the program is run and the following menu appears:

PROGRAM DATATRAN

INPUTS MUST BE IN CAPITAL LETTERS

SELECT FUNCTION:

- 1) STATE PLANE GEOGRAPHICS, NAD27
- 2) STATE PLANE GEOGRAPHICS, NAD83
- 3) NAD27 TO NAD83
- 4) NAD83 TO NAD27
- 5) OTHER DATUM TRANSFORMATION

INPUT FUNCTION NUMBER:

The user enters the number corresponding to the conversion desired. For this sample run, a 3 is entered and the following additional menu appears:

SELECT INPUTS/OUTPUTS:

- 1) GEO INPUTS GEO OUTPUTS
- 2) GEO INPUTS SP OUTPUTS
- 3) SP INPUTS GEO OUTPUTS
- 4) SP INPUTS SP OUTPUTS

The user enters the number corresponding to the desired combination of inputs/outputs. For this sample run, a l is entered. Recall that a NAD83 to NAD27 conversion with state plane inputs is not possible with this software. Therefore, if a 4 is entered for the initial menu and a 3 or 4 is entered for the second menu, then an error message is displayed and another selection must be made.

The user is then prompted for the names of the control file, the common file, and the output file. The appropriate names consisting of a maximum of eight characters are entered.

The following prompt is then displayed:

DO YOU WANT A FULL LEFTI LISTING WITH -

- 1 COORDINATES OF COMMON STATIONS
- 2 RESIDUALS AT COMMON STATIONS
- 3 TRANSFORMED COORDINATES AND THEIR CORRECTIONS
- 4 CHANGES AND INTERSECTION CORNERS
- 5 SHIFTS FOR EACH STATION IN SECONDS
- 6 SHIFTS FOR EACH STATION IN METERS ANSWER Y OR N ???

The items listed in this prompt are available for output to the datum conversion statistics file. The user enters a Y if all six items are desired. If an N is entered, then the user chooses which of the individual items, if any, are desired.

The datum transformation is computed, and the final output file is as follows:

80	DUP 1924-SAMPLE FILE	47070784536N1223952382550W
80	TATSOLO 1935-SAMPLE FILE	47072884900N1223933484030W
*80 *	HURST 1905-SAMPLE FILE	47050081643N1223048117490W
80	TACOMA 1905-SAMPLE FILE	47043710622N1222608565760W
80	SAMPLEV459-1986-FILE	47100935002N1223643269622W
80	RAIN 1905-SAMPLE FILE	46500533690N1224112573050W

This file has the output file name specified by the user and lists the NAD83 coordinates of the control and common stations according to Format B. The conversion statistics file with the items specified by the user is also produced. This file has the output file name specified by the user with the extension ".STS." For example, if the user entered "FILE.OUT" as the final output file name, then this would be the name of the file shown above. The conversion statistics would then have the name "FILE.STS." The conversion statistics file with all six items for this sample conversion is as shown on the following two pages.

CONCLUSION

DATATRAN provides users with an accurate and easy-to-use method for converting between NAD27 and NAD83. The program also offers the flexibility of having inputs/outputs in geodetic or state plane values. Three or more stations with known coordinates on both datums are needed. A least squares adjustment is then applied to the unknown station(s) to determine the coordinate(s) on the new datum.

Reference

Computer Programs "LEFTI", "PCTOGP", and "GPPC83"; National Geodetic Survey - Information Branch, National Oceanographic & Atmospheric Administration, Rockville, Maryland 20852.

COORDINATES OF C	OMON STATIONS						
STATION		OLD LATITUD	P 0:0 / 0 WG: 7 HDE	NEW LATITUDE	NEW LONGITUDE		
SIRIIVE		OPS PETITION	E OUD HORSELINE	SEW MAILINE	NEW PORGITIONS		
DUP 1924-SAMPLE	FILE	47 7 8.48	400 122 39 47.93300	47 7 7.94536	122 39 52.38255		
BURST 1905-SAMPL	E FILE	47 5 1.45	800 122 30 43.67300	47 5 0.81643	122 30 48.11749		
TACOMA 1905-SAMP	LE FILE	47 4 37.74	600 122 28 4.13000	47 4 37.10822	122 26 8.56576		
SAMPLEV459-1986-		47 10 9.35	002 122 38 43.25962	47 10 9.35002	122 36 43.26962		
RAIN 1905-SAMPLE	FILE	46 50 5.97	300 122 41 8.13200	46 50 5.33690	122 41 12.57305		
					PAGE 2		
RESIDUALS AT COM	MON STATIONS			RESIDUALS A	•		
STATION		HEW LATITUDE	NEW LONGITUDE	1 E			
				(METERS) (METER	3)		
DUP 1924-SAMPLE	FILE	47 7 7,845	36 122 39 52.38255				
				-10.975 -26.238			
EURST 1905-SAMPLI	I FILE	47 5 0.816	43 122 30 48.11749	1 200 00 220			
TACOMA 1905-SAMPE	LE FILE	47 4 37,106	22 122 26 8.56576	1.798 -22.353			
				8.438 -21.666			
SAMPLEV459-1986-1	FILE	47 10 9.350	02 122 36 43.26962	12.938 81.057			
RAID 1905-SAMPLE	FILE	46 50 5.336	90 122 41 12.57305				
				-12.199 9.201			
					PAGE 3		
TRANSFORMED COORS	DIBATES AND TEN	IIR CORRECTIONS			PAGE 3	PESID	DALS AT
TRANSFORMED COORS	DIBATES AND TEN			NEW LATITUDE			
			E OLD LONGITUDE	NEW LATITUDE		ı	JALS A? E (METERS)
STATION	1	OLD LATITUD	CLD LONGITUDE		NEW LONGITUDE	II (METRIES)	E
STATION	1	OLD LATITUD			1EV LONGITUDE 122 39 33.48403	II (METRIES)	E (HETERS)
STATION	1	OLD LATITUD	CLD LONGITUDE		NEW LONGITUDE	# (1877335)	E (HETERS)
STATION TATSOLO 1935-SAM	! PLE FILE	OLD LATITUD	CLD LONGITUDE	47 7 28.84900	1EV LONGITUDE 122 39 33.48403	# (1877335)	E (NETERS)
STATION TATSOLO 1935-SAM	! PLE FILE	OLD LATITUD	0LD LONGITUDE	47 7 28.84900	1EV LONGITUDE 122 39 33.48403	# (1877335)	E (NETERS)
STATION TATSOLO 1935-SAM	! PLE FILE	OLD LATITUD	0LD LONGITUDE	47 7 28.84900 M - HAD27 DATUM	122 39 33.48403 PAGE 4	(METERS) -10.498	E (HETERS)
STATION TATSOLO 1935-SAM	PLE FILE	OLD LATITUDE 47 7 29.48	OLD LONGITUDE 122 39 29.14900 SHIFT = HADGS DATU	47 7 28.84900 M - HAD27 DATUM WEW	1EV LONGITUDE 122 39 33.48403	# (1877335)	E (HETERS)
STATION TATSOLO 1935-SAME CRANGES AT INTERS	PLE FILE SECTIONS POINTS	OLD LATITUDE 47 7 29.48	COLD LONGITUDE 122 39 29.14900 SHIFT = HADGS DATU SHIFT ARW	47 7 28.84900 M - HAD27 DATUM WEW	122 39 33.48403 PAGE 4 SHIFT	(METERS) -10.496 SRIPT	E (HETERS)
STATION TATSOLO 1935-SAME CRANGES AT INTERS	PLE FILE SECTIONS POINTS OLD LONGITUDE	OLD LATITUD: 47 7 29.48	COLD LONGITUDE 100 122 39 29.14900 SHIFT - HADGS DATU SHIFT HEW LOH. LATITUD SEC	47 7 28.84900 M - HAD27 DATUM HEW LONGITUDE	122 39 33.48403 PAGE 4 SHIFT METERS LAT	(METERS) -10.496 SEIFT METERS LONG	E (HETERS)
STATION TATSOLO 1935-SAM CHANGES AT INTES OLD LATITUDE	PLE FILE SECTIONS POINTS	OLD LATITUDE 47 7 29.48 SHIFT LAT. SEC -0.91551	COLD LONGITUDE 100 122 39 29.14900 SHIFT = HADGS DATU SHIFT ARV LOH. LATITUD	47 7 28.84900 M - HAD27 DATUM HEW LONGITUDE 449 122 30 4.9483	122 39 33.48403 PAGE 4 SHIFT MEYERS LAT	SHIPT MYTERS LONG 103.92	E (HETERS)
STATION TATSOLO 1935-SAM CHANGES AT INTENS OLD LATITUDE 46 52 30	PLE FILE SECTIONS POINTS OLD LONGITUDE 122 30 0	OLD LATITUD: 47 7 29.48 SHIFT LAT. SEC -0.91551 -0.73982	E OLD LONGITUDE 500 122 39 29.14900 SHIFT = HADGS DATU SHIFT HEW LOH. LATITUD SEC 4.94937 46 52 29.28 4.41949 46 52 29.26	47 7 28.84900 M - HAD27 DATUM HEW LONGITUDE 449 122 30 4.9483	110 LONGITUDE 122 39 33.48403 PAGE 4 SHIFT METERS LAT 7 -27.47 9 -22.19	(METERS) -10.496 SEIFT METERS LONG	E (HETERS)
TATSOLO 1935-SAME CHANGES AT INTES OLD LATITUDE 46 52 30 46 52 30	PLE FILE SECTIONS POINTS OLD LONGITUDE 122 30 0 122 37 30	OLD LATITUD: 47 7 29.48 SHIFT LAT. SEC -0.91551 -0.73982 -0.41046 -0.61513	SHIFT = HADGS DATU SHIFT = HADGS DATU SHIFT LOB. LATITUD SEC 4.94937 46 52 29.26 4.41949 46 52 29.28 4.41949 46 52 29.58 4.58732 46 59 59.38	47 7 28.84900 M - WAD27 DATUM WEW LONGITUDE 449 122 30 4.9483' 918 122 37 34.41941 918 122 45 4.40816 447 122 45 4.40816	122 39 33.48403 PAGE 4 SHIFT METERS LAT 7 -27.47 -22.19 1 -12.31 -18.45	SHIP? MYTERS LONG 103.92 92.81	E (HETERS)
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TATSOLO 1935-SAME CHARGES AT INTERS OLD LATITUDE 46 52 30 46 52 30 46 52 30 47 0 0 47 0 0 47 0 0 47 7 30	PLE FILE OLD LONGITUDE 122 30 0 122 37 30 122 45 0 122 37 30 122 45 0 122 30 0	OLD LATITUD: 47 7 29.48 SHIFT LAT. SEC -0.91551 -0.73982 -0.41046 -0.61513 -0.36481 -0.19401 -0.60861	SHIFT = HADGS DATU SHIFT = HADGS DATU SHIFT LOH. LATITUD SEC 4.94937 46 52 29.26 4.41949 46 52 29.26 4.40818 46 52 29.58 4.58732 46 59 59.63 3.98207 48 59 59.80 3.68802 47 07 29.39	47 7 28.84900 M - WAD27 DATUM WEW LONGITUDE 449 122 30 4.9483' 918 122 37 34.41941 954 122 45 4.4081 487 122 30 4.5873' 519 122 37 34.3798' 599 122 45 3.9820' 139 122 30 3.8880'	SHIFT METERS LAT 7 -27.47 9 -22.19 1 -18.45 7 -10.94 7 -5.82 2 -18.26	SHIFT MYTES LONG 103.92 92.81 92.57 96.33 91.98 83.62 77.45	E (NETERS)
TATSOLO 1935-SAME CRANGES AT INTERS OLD LATITUDE 46 52 30 46 52 30 46 52 30 47 0 0 47 0 0 47 0 0	OLD LONGITUDE 122 30 0 122 37 30 122 45 0 122 37 30 122 45 0 122 37 30 122 45 0	OLD LATITUD: 47 7 29.48 SHIFT LAT. SEC -0.91551 -0.73982 -0.41046 -0.61513 -0.36481 -0.19401 -0.60861 -0.51476	SHIFT = HADGS DATU SHIFT = HADGS DATU SHIFT LOW. LATITUD SEC 4.94837 46 52 29.26 4.41949 46 52 29.26 4.40818 46 52 29.28 4.40818 46 52 29.38 4.58732 46 59 59.38 4.37987 46 59 59.80	47 7 28.84900 M - HAD27 DATUM FEW LONGITUDE 449 122 30 4.9483' 018 122 37 34.41941 954 122 45 4.0814 487 122 30 4.5873' 519 122 37 34.3798' 599 122 45 3.9820' 139 122 30 3.6880' 524 122 37 33.3891'	SHIFT MEYERS LAT 7 -27.47 9 -22.19 3 -12.31 1 -18.45 7 -5.82 2 -18.26 4 -15.44	SHIFT MYTES LONG 103.92 92.81 92.57 96.33 91.98 83.62 77.45 71.17	E (NETERS)

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JOB STATISTICS

PROJECT TITLE: CONVERSION

OLD

SHIFT W SHIFT E ROT. ANGLE SCALE PPW)

A 5378206.400 5378:37.000 1/F 294.9786982 298.2572221

VALUE 203.600 -46.838 233.011 24.52 S.E 27.789 27.789 197.560 958.29

C.M. 122.5833333 122.5833333

GAUSS-KRUEGER PROJECTION

STANDARD ERROR OF UNIT WEIGHT = 31.573

6 STATIONS

5 COMMON STATIONS

SHIFT : HADES DATUM - HADET DATUM

TO. STATION HAME LATITUDE 1 TATSOLO 1935-SAMPLE FILE

TAD 1927 DATUM LONGITUDE 47 7 29.48600 122 39 29.14900

MAD 1983 DATUM LATITUDE LONGITUDE

47 7 28.84900 122 39 33.48403

LATITUDE LONGITUDE SHIFT (SECOEDS)

-0.63700

SHIFT (SECOMOS)

4.33503

SOME STATISTICS ON THESE DATA: NUMBER OF POINTS IN AREA :

AVERAGE HAD 1983 LATITUDE = 47 DEG 7 MIN 28.85 SEC

AVERAGE HAD 1983 LONGITUDE = 122 DEG 39 MIH 33.48 SEC

POSITION SHIFTS (MAD 1983 MINUS MAD 1927):

AVERAGE LATITUDE SHIPT = -0.637 SECORDS = -19.7 METERS

AVERAGE LONGITUDE SHIFT = 4.335 SECONDS = 91.4 METERS

SHIFT - HADES DATUM - HADET DATUM

BO. STATION NAME 1 TATSOLO 1935-SAMPLE FILE

HAD 1927 DATUM LATITUDE LONGITUDE 47 7 29.48600 122 39 29.14900

MAD 1983 DATUM LATITUDE LONGITUDE

47 7 28.84900 122 39 33.48403

LATITUDE LONGITUDE SHIFT SEIFT (METERS) (NETERS)

-19.67 91.37

SOME STATISTICS OF THESE DATA: FUNDER OF POINTS IN AREA = 1

AVERAGE HAD 1983 LATITUDE = 47 DEG 7 MIH 28.85 SEC

AVERAGE MAD 1963 LONGITUDE : 122 DEG 39 MIN 33.48 SEC

POSITION SHIFTS (MAD 1983 MINUS MAD 1927):

AVERAGE LATITUDE SHIFT = -0.637 SECONDS = -19.7 METERS

AVERAGE LONGITUDE SHIFT = 4.335 SECONDS = 91.4 METERS

		APPENDIX	
Format A:	Common File		
	1-6	Sequence Number	(optional)
	7-10	Blank	(o p (o o o o o o o o o o o o o o o o
	11-13	Station Serial Number	(optional)
	14	Blank	- p - 2
	15-44	Station Name	
	45-55	Geodetic Latitude: Deg-Min	-Sec to 5
		decimal places, decimal pobetween col 50-51 (DDMMSSs	int implied
	56	Direction of Latitude: N o	
	57-68	Geodetic Longitude: Deg-Mi	
	· •	decimal places, decimal po between 63-64 (DDDMMSSssss	int implied
	69	Direction of Longitude: E	
	70-75	Elevation of mark above me	
	-	in meters, decimal point i	mplied
	76	between 73-74 (EEEEee)	(optional)
	=	Elevation code	(optional)
	77-78	State or Country Code	(optional)
	79-80	Station Order and Type	(optional)
Format B:	Geodetic Cont	rol File	
	1-6	Sequence Number	(optional)
	7-10	Data Code (*80*)	
	11-13	Station Serial Number	(optional)
	14	Blank	
	15-44	Station Name	
	45-55	Geodetic Latitude: Deg-Min decimal places, decimal po	int implied
		between col 50-51 (DDMMSSs	
	56	Direction of Latitude: N o	
	57-68	Geodetic Longitude: Deg-Mi decimal places, decimal po	int implied
	69	between 63-64 (DDDMMSSssss	
	70-75	Direction of Longitude: E	
	70-75	Elevation of mark above me in meters, decimal point i between 73-74 (EEEEee)	
	76	Elevation code	(optional)
	77-78	State or Country Code	(optional)
	79-80	Station Order and Type	(optional)
		boaton oracl and type	(opvional)

Format C: State Plane Control File

Carlo Carlo Carlo

	1-6 7-10	Sequence Number Data Code (*81*)	(optional)
	11-13	Station Serial Number	(optional)
	14	Blank	(optional)
	15-44	Station Name	1
	45-54	X Coordinate, in feet, to t	hree decimal
		places, decimal point impli 51-52 (XXXXXXXXXX)	ed between
IS	55-65	Y Coordinate, in feet, to t	hree decimal
8		places, decimal point impli 62-63 (YYYYYYYYYyyy)	ed between
	66-69	State and Zone code (SSZZ)	1
K	70-75	Elevation of mark above mea	n sea level.
		in meters, decimal point im (EEEEee)	
8	76	Elevation Code	(optional) (optional)
	77-78		(optional)
	79-80		(optional)
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